

AP Chemistry – Electrochemistry, Nuclear Chemistry, Comprehensive Exam

Name: _____ Date: _____ Period: _____

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1. A standard electrochemical cell is made by dipping a silver electrode into a 1.0M Ag^+ solution and a cadmium electrode into a 1.0M Cd^{2+} solution.

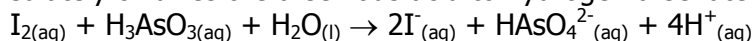
a. What is the spontaneous chemical reaction, and what is the maximum potential produced by the cell?

Reaction: _____ Cell Potential: _____ V

b. What would be the effect on the potential of this cell if sodium sulfide were added to the Cd^{2+} half-cell and CdS were precipitated? Explain.

c. What would be the effect on the potential of the cell if the size of the silver electrode were doubled?

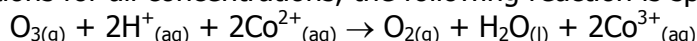
2. In an analytical determination of arsenic, a solution containing arsenious acid, H_3AsO_3 , potassium iodide, and a small amount of starch is electrolyzed. The electrolysis produces free iodine from iodide ion, and the iodine immediately oxidizes the arsenious acid to hydrogen arsenate ion, HAsO_4^{2-} .



When the oxidation of arsenic is complete, the free iodine combines with the starch to give a deep blue color. If, during a particular run, it takes 65.4s for a current of 10.5mA to give an endpoint (indicated by the blue color), how many grams of arsenic are present in the solution?

Answer: _____ g As

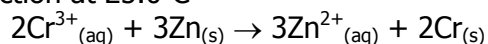
3. Under standard conditions for all concentrations, the following reaction is spontaneous at 25.0°C.



If $[\text{H}^+]$ is decreased so that the pH = 9.10, what value will E_{cell} have, and will the reaction be spontaneous at this $[\text{H}^+]$? $E^{\circ}_{\text{Co}^{3+}/\text{Co}^{2+}} = 1.82\text{V}$; $E^{\circ}_{\text{O}_3/\text{H}_2\text{O}} = 2.07\text{V}$

$E_{\text{cell}} =$ _____ V Spontaneous? _____

4. Consider the following cell reaction at 25.0°C



a. Calculate the standard cell potential of this cell from the standard electrode potentials

$$E^{\circ}_{\text{cell}} = \text{_____} \text{V}$$

b. From the above cell potential, calculate ΔG° for the reaction.

$$\Delta G^{\circ} = \text{_____} \text{kJ}$$

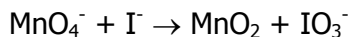
c. Given that the $\Delta H^{\circ}_{\text{f}}$ for $\text{Cr}^{3+} = -143.5 \text{kJ/mol}$ and $\Delta H^{\circ}_{\text{f}}$ for $\text{Zn}^{2+} = -153.9 \text{kJ/mol}$, calculate ΔH° for the reaction.

$$\Delta H^{\circ} = \text{_____} \text{kJ}$$

d. Use the values of ΔH° and ΔG° calculated above to determine ΔS° for the reaction.

$$\Delta S^{\circ} = \text{_____} \text{J/K}$$

5. Balance the following oxidation-reduction reaction which takes place in basic medium.



Answer: _____

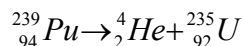
6. Polonium-210 has a half-life of 138.4 days, decaying by alpha emission. Suppose the helium gas originating from the alpha particles in this decay were collected. What volume of helium at 25.0°C and 735 mmHg could be obtained from 1.0000 g of polonium dioxide, PoO_2 , in a period of 48.0 h?

Answer: _____ L

7. A sample of sodium phosphate, Na_3PO_4 , weighing 54.5 mg contains radioactive phosphorus-32 (with mass of 32.0 amu). If 15.6% of the phosphorus atoms in the compound is phosphorus-32 (the remainder is naturally occurring phosphorus), how many disintegrations of this nucleus occur per second in this sample? Phosphorus-32 has a half-life of 14.3 d.

Answer: _____ disintegrations/second

8. a. Plutonium-239 has been used as a power source for heart pacemakers. What is the energy obtained from the following decay of 215mg of plutonium-239 (Pu-239 = 239.05216u; He-4 = 4.00260u; U-235 = 235.04392u)



Answer: _____ kJ

b. Suppose the electric energy produced from this amount of plutonium-239 is 25.0% of this value. What is the minimum grams of zinc that would be needed for the standard voltaic cell
 $\text{Zn} \mid \text{Zn}^{2+} \parallel \text{Cu}^{2+} \mid \text{Cu}$ to obtain the same electric energy?

Answer: _____ g zinc

9. The half-life of calcium-47 is 4.536 days and it decays by the emission of a beta particle.
a. Write a balanced equation for the decay of Ca-47

Answer: _____

b. If 10.0 μg of Ca-47 is needed for an experiment, what mass of ${}^{47}\text{CaSO}_4$ must be ordered if it takes 48h for it to arrive from the supplier?

Answer: _____ g ${}^{47}\text{CaSO}_4$

10. Sulfuryl chloride is used in organic chemistry as a chlorinating agent. At moderately high temperatures it decomposes as follows:



With $K_c = 0.045$ at 650.K.

a. A sample of 8.25g of SO_2Cl_2 is placed in a 1.00L reaction vessel and heated to 650.K. What are the equilibrium concentrations of all the species?

$[\text{SO}_2\text{Cl}_2] =$ _____ M; $[\text{SO}_2] =$ _____ M; $[\text{Cl}_2] =$ _____ M

b. What percentage of SO_2Cl_2 has decomposed?

Answer: _____%

c. If 5.00g of chlorine is inserted into the reaction vessel, what qualitative effect would this have on the fraction of SO_2Cl_2 that has decomposed?

11. The following data were collected for the reaction $\text{A(g)} + \text{B(g)} \rightarrow \text{Products}$

Experiment	$[\text{A}_0](\text{M})$	$[\text{B}_0](\text{M})$	Rate (M/s)
1	0.0100	0.100	1.0×10^{-3}
2	0.0300	0.100	3.0×10^{-3}
3	0.0300	0.300	2.7×10^{-2}

a. Determine the rate law for this reaction.

Answer: _____

b. Calculate the rate constant.

Answer: _____

c. Calculate the rate when $[\text{A}] = 0.200\text{M}$ and $[\text{B}] = 0.200\text{M}$

Rate = _____

12. Tungsten has a body-centered cubic lattice with all atoms at the lattice points. The edge length of the unit cell is 316.5pm. The atomic mass of tungsten is 183.8u. Calculate the density of W.

Answer: _____g/cm³

13. The vapor pressure of benzene is 100.0mmHg at 26.1°C and 400.0mmHg at 60.6°C. What is the boiling point of benzene at 760.0mmHg?

Answer: _____°C

14. A molecular compound is composed of 60.4% Xe, 22.1% O and 17.5% F, by mass. If the molecular weight is 223u

a. Draw a Lewis structure for the molecular compound

b. Predict the molecular geometry in terms of VSEPR and valence bond theory.